Pseudo-security diagnostics for increasing the sustainability of a regional development

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Abstract. This article presents a methodological approach to assessing the real state of a regional socio-economic system from the standpoint of economic security and pseudo-security. The ongoing economic uncertainty inherent in the development of Russian regions has intensified with the Covid-19 pandemic. In this context, it is becoming insufficient to apply classical principles of economic security, which is characterized by the ability to pursue a company's own economic policy thus responding to abrupt geopolitical changes in the form of measures to localize and neutralize threats. A mathematical model is proposed for evaluating pseudo-security, which can be applied when assessment of the generally accepted indicators does not contribute to maintaining sustainability. It is proposed to consider the mutual influence of various indicators and their latent behaviour to avoid ineffective spending on the preservation/strengthening of a particular developmental path. The efficiency of the proposed methodology was verified using the example of the subjects of the Ural Federal District (UFD).

1 Introduction

At the onset of 2020, when the COVID-19 pandemic began to unfold, all Russian regions faced a challenging situation connected with a declining economic growth and economic activity as the whole. Although economic security is an important indicator of the state of regional socio-economic systems, this parameter cannot be considered as a panacea for all problems, requiring consideration of different aspects of economic development (economic potential, growth and sustainability). This is particularly important in the context of delayed and controversial statistical information, abundance of reporting indicators and multiple interpretations of the economic results. In this article, we focus on the phenomenon of pseudo-security, which not only affects the current state of any economic system, but also allows the relationship between indicators and the overall economic state of such a system to be properly assessed.

Certain difficulties arise when there is a need to process a large number of indicators, particularly in forecasting a region's development. Therefore, we used a reduced set of

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indicators (8 instead of 43) when demonstrating the application of the developed pseudo-security model.

2 Brief contextual information

Over its short history, new Russia has experienced several crises, which were manifested in the declining GDP dynamics, growing poverty, shrinking population and a significant increase in mortality.

This was accompanied by various management errors, leading to ineffective response to threats and challenges [1].

Threats:

1. The impact of economic sanctions on key sectors of the economy.
2. The deformed structure of the economy with a focus on capital-intensive industries.
3. Insufficient development of energy-saving technologies.
4. Resource orientation of Russian exports.
5. Growth in the number of the poor.
6. Corruption and shadow economy.
7. Ineffective public administration.

An analysis of the implementation of national strategic projects planned for 2018–2024 showed that one third of these orders has not been implemented. Russia has failed to reach the planned stable values of economic development. The principle of catch-up modernization has not justified itself. Planning has been reduced to the development of simulation models, where management is only simulated, remaining vague and inefficient [2-4].

The strategic framework (state strategies of socio-economic development, national and economic security, spatial strategy) raised controversial opinions within the population. There is an obvious decline in trust within the “population-power-business” triad.

Therefore, it seems reasonable to consider economic development from the standpoint of both economic security and taking into account pseudo-security. It is expedient to realise new developmental vectors, in order to overcome the scientific and technological backwardness and improve the overall quality of life.

2.1 Brief analysis of the economic security of the subjects of the Ural Federal District

The economic security of a region is a set of conditions and factors that characterise the current state of its economy, stability, sustainability, progress and certain independence in the processes of integration within the Russian economy. A region’s economic security is expressed in the ability:

– to pursue a region’s own economic policy within the Federation;
– to respond effectively to abrupt geopolitical changes;
– to take action and carry out activities in urgent socio-economic situations.

Within the framework of this definition, we developed a comprehensive methodology for evaluating the level of economic security [5].

Over the past seven years, all subjects of the Ural Federal District, along with Russia as a whole, have gone through the periods of stagnation (2013–2014) and recession (2015–2016), which again turned into stagnation (2017–2019) and finally came under the pressure of Covid-19.

Our calculations made for various economic spheres showed the following results (hereinafter the crisis levels are given as: N – relatively normal situation; PC3 – pre-crisis critical stage; C1 – unstable stage of the crisis; C2 – threatening stage of the crisis; C3 – emergency stage of the crisis):

2.2 Investment security

The indicator "The ratio of the volume of investments in fixed assets to the gross regional product" for all subjects of the Ural Federal District (except for the Kurgan Oblast PC3 → C1) was at the average level. In the Sverdlovsk and Chelyabinsk Oblasts, this indicator decreased significantly (PC3). Its highest levels were recorded in the Yamalo-Nenets Autonomous Okrug (YNAO) (N; 45-50%).

2.3 Industrial security

In general, in the Ural Federal District, the fall in industrial safety reached the level of C1 in 2014–2018, which can be explained by a significant increase in the depreciation of fixed assets (YNAO and Khanty-Mansi Autonomous Okrug (KhMAO) – 70%).

2.4 Scientific and technical security

The level of scientific and technical security was C2 in the Kurgan Oblast and C3 in the KhMAO, YNAO and Tyumen Oblast (south). The share of internal expenditures on research and development in GRP did not rise over the level of 1% (only in the Sverdlovsk Oblast, it was higher than 1.5%). Most of the subjects of the Ural Federal District are currently in the crisis zone according to the indicator "The share of innovative products in the total volume of industrial production". It is only the Sverdlovsk Oblast that demonstrates a relatively better dynamic (C1).

2.5 Living standards

The level of poverty is growing, with the middle class increasingly comprising a negligible share. The ratio of funds (the ratio of 10% of the most and 10% of the poorest population) reaches 10–15. There is an excessive debt load of the population.

3 Methods and Data

In order to reveal hidden regularities, both qualitative and quantitative, of the interaction of various indicators included in either one or several socio-economic modules, we used a shift coefficient of cross-correlation. According to research works [6-8], this coefficient is calculated as follows:

$$C_{ij} = \frac{\sum_{t=1}^{k}(x_i(t)-\bar{x}_i)(x_j(t)-\bar{x}_j)}{\sqrt{\sum_{t=1}^{k}(x_i(t)-\bar{x}_i)^2 \sum_{t=1}^{k}(x_j(t)-\bar{x}_j)^2}} \tag{1}$$

where t – time, $x_i(t)$ – value of the indicator at time t, $x_j(t)$ – value of the second indicator other than $x_i(t)$, k — maximum value of t , $\bar{x}_i$— average value of the indicator, (i, j – indicator number).

The conducted analysis of the values determined by (1) made it possible to select both the main indicators and the main schemes of their interaction (Table 1).

Table 1. Schemes of interaction between the indicators and cross-correlation coefficients.

Main indicator	Indicators of the first and second order of influence	Cross-correlation coefficient $C_{ij}(0)$
1	1←2	$C_{12}(0) = 0.768$
2	2←1	$C_{21}(0) = 0.770$
3	3 ← (4; 2)	$C_{34}(0) = 0.718$ $C_{32}(0) = -0.711$
4	4 ← (6; 5)	$C_{46}(0) = 0.806$ $C_{45}(0) = 0.592$
5	5←6	$C_{56}(0) = 0.581$
6	6←3	$C_{63}(0) = 0.674$
7	7 ← (2; 4)	$C_{72}(0) = -0.929$ $C_{74}(0) = 0.846$
8	8←1	$C_{81}(0) = -0.779$

Note: The arrows show which indicator affects the main indicator. In brackets, the indicator of the first order of influence is given first.

Indicators:
1. Depreciation of fixed assets.
2. The ratio of the region's exports to the GRP.
3. Consumer price index.
4. The ratio of the average per capita income to the subsistence level.
5. Total unemployment rate.
6. Life expectancy at birth.
7. Per capita satisfaction of the need for basic types of agricultural products in accordance with medical nutritional standards.
8. Specific emissions of harmful substances into the atmosphere from stationary sources of pollution.

This selection was carried out not only in terms of the coefficients of mutual influence, but also in terms of the economic interaction of the main indicator and indicators of the first and second order of influence (economic tomography). Economic tomography is the information on the effect of specific factors at different levels of the socio-economic system under study, allowing the selection and assessment of preferences, as well as simulation of the extreme values of individual modules and the system as a whole.

Table 1, as an example, shows the main schemes of interaction between indicators and their coefficients $C_{ij}(0)$ [9-11].

The results presented in Table 1 allow a quantitative description of economic security. Indicators were selected using the criterion $C_{ij}(0) > 0.5$. The economic meaning of interacting indicators was considered such that to avoid multi-collinearity, repetition of interacting indicators and illogical interaction patterns. The maximum value of the correlation coefficient is typical for the pair (5←4) accounting for $C_{74}(0) = 0.846$; the lowest – for the pair (4←6) accounting for $C_{56}(0) = 0.581$ (the pair was selected considering the economic interaction of indicators). The maximum inverse type of interaction is characteristic of the triple type of interaction (7 ← (2; 4)) with a coefficient of $C_{72}(0) = -0.929$. This means that the lower the "Degree of per capita satisfaction of the need for basic agricultural products in accordance with medical nutritional standards", the higher "The ratio of the export of the territory's production to the GRP", and vice versa.

The result of applying this approach is grouping of interacting indicators in 4 pairs and 2 triplets.

3.1 Pseudo-security

During the research process, we revealed a specific state of a regional socio-economic system, which is characterized by normal levels of economic security although having prerequisites for the regression of the system in the medium term. Such a state is defined as pseudo-security, when the system may lose the ability to develop steadily, although showing no disturbing signs at the moment. This is an imitation (under the same trend of indicators), when there is a change in the qualitative assessment of the indicator in relation to the entire composition of indicators.

Such a situation is frequently observed in our daily practices. For example, an increase in higher education funding leads to either an increase in the number of university graduates in certain specialities or an increased outflow of graduates (especially from leading universities) to work abroad. As a result, overestimated/underestimated real opportunities and ignored hidden threats create the feeling of complacency, unavoidably causing mistakes and irrational use of funds.

On the basis of cross-correlation coefficients, let us single out the total effect of the first- and second order indicators Δ in the form:

$$\Delta = x_i^{/} - x_i = x_j \cos\alpha_{ij} + x_k \cos\alpha_{ik}. \quad (2)$$

This effect consists of two terms: *the natural change of the influencing indicators* Δf and the term responsible for the *pseudo-security* $\Delta\psi$: $\Delta = \Delta f + \Delta\psi$.

We introduce pseudo-security in the form

$$\Delta\psi = x_j\left(sign(\cos\alpha_{ij}) - \cos\alpha_{ij}\right) + x_k\left(sign(\cos\alpha_{ik}) - \cos\alpha_{ik}\right), \quad (3)$$

where $sign$ is the sign function.

Table 2 shows an example of a triple interaction of indicators. The total effect of the first- and second-order indicators on the main indicator is calculated. For the period from 2008 to 2010, the distortion of the main indicator, which is responsible for pseudo-security, was constantly growing (positive distortion value), leading to a deterioration of the main indicator (in 2009, the level of C2 taking into account the interaction, compared to PC3 without interaction). In 2017, the indicator taking into account the interaction shows a lower value compared to the statistics, which is confirmed by the negative value of the pseudo-security contribution.

Table 2. Effects of the first- and second-order indicators on the main indicator (example of the Sverdlovsk Oblast).

	Indicator	2008	2009	2010	2016	2017	2018
Main indicator	Ratio of the average per capita income to the subsistence level	0.893 PC3	0.915 PC3	0.907 PC3	0.990 PC3	0.993 PC3	1.047 C1
Indicator of the first order of influence	Life expectancy at birth	0.400 PC2	0.283 PC2	0.200 PC1	-0.003 N	-0.170 N	-0.193 N
Indicator of the second order of influence	Total unemployment rate	-0.172 N	0.462 PC2	0.500 PC2	0.077 PC1	-0.052 N	-0.172 N

Indicator of joint influence		1.14 C1	1.417 C2	1.364 C1	1.033 C1	0.825 PC3	0.790 PC3
Δ	Total impact of the first- and second-order indicators of influence	0.221 19.8%	0.502 35.4%	0.457 33.5%	0.043 4.2%	-0.168 -20.3%	-0.257 32.6%
	The distortion of the main indicator (pseudo-security)	0.007 0.7%	0.243 17.2%	0.243 17.8%	0.031 3%	-0.054 -6.6%	-0.108 -13.6%
	Natural change in the indicator	0.213 19.1%	0.258 18.2%	0.214 15.7%	0.012 1.2%	-0.114 -13.7%	-0.150 -19%

Note: Crisis thresholds (from N to C3) correspond to a scale where: N - from -2 to 0; PC1 - from 0.001 to 0.332; PC2 - from 0.333 to 0.665; PC3 - from 0.666 to 0.999; K1 - from 1 to 1.399; K2 - from 1.4 to 1.799; K3 - from 1.8.

3.2 Potential energy of interaction between the indicators

Economic security is a complex nonlinear system of interacting indicators. For such a system, we introduce a scalar function U_{ij} - the potential interaction energy (analogue of the potential function in a gravitational field [12]), depending on the modulus of the difference NE (normalized estimate) $|x_i - x_j|$ of two interacting indicators x_i and x_j in the form

$$U_{ij} = -\frac{\cos \alpha_{ij}}{|x_i - x_j|} \tag{4}$$

This function depends on the difference between the NE components of the economic security module, characterizing the impact of the first- and second-order indicators on the main indicator. On the other hand, in addition to the interaction between indicators, it is necessary to take into account rapid changes that these indicators undergo. To this end, let us introduce a scalar velocity function K_i in the form

$$K_i = \frac{(\vartheta_i)^2}{2}, \tag{5}$$

where ϑ_i is the rate of the i indicator. Combining (4) and (5), we obtain the scalar function E_{ij}– the complete energy function that takes into account the rate of changes in the indicators, as well as their interaction (mutual influence). For the main and first-order indicators, E_{ij} will take the form

$$E_{ij} = K_i + K_j + U_{ij} = \frac{(\vartheta_i)^2}{2} + \frac{(\vartheta_j)^2}{2} - \frac{\cos \alpha_{ij}}{|x_i - x_j|}. \tag{6}$$

The rate of changes in the energy function dE_{ij}/dt reveals the presence of an external force, in addition to the first- and second-order indicators. This force either leads to an increase in the main indicator ($dE_{ij}/dt > 0$) and a decrease in the indicator ($dE_{ij}/dt < 0$) or has no affect on the main indicator.

According to these characteristics, the following types of interaction between indicators with can be distinguished.

3.3 Effects of the first- and second-order indicators on the main indicator

First, let us consider the impact of the first-order indicator on the main indicator. Depending on the rate of changes in the indicators, the following three types of behaviour can be distinguished: a) a decrease in the indicator towards the normal (Type A); b) an increase in the indicator to crisis levels (Type B); c) stationary behaviour – small changes in the indicator within one level (Type C).

These three types of behaviour can be described by the following characteristics: the rate of changes in the indicators ϑ_i, scalar velocity function K_i, as well as the potential energy of interaction U_{ij}. The scalar velocity function describes an abrupt change in the trend of the indicator, while its time derivative dK_i/dt captures the transition between the levels. The influence of the levels themselves can be described by the resistance of the levels, which takes into account the movement of the indicator either between or within the levels, depending on the difference between the normalized indicator and the fixed normalized estimate. Therefore, let us introduce the concept of "level viscosity" in the form:

$$\eta(x) = \eta_0 e^{x-x_0} \tag{7}$$

where η_0, $x_0$are constants inherent in this indicator.

4 Results

Within the framework of these three types of behaviour of the main indicator, the following interactions between this indicator and the first-order indicator are possible:

Type A1: a simultaneous decrease of the main i and the first-order indicator j. This case is characterized by a negative value of the rate $\vartheta_i < 0, \vartheta_j < 0$. Both a sharp decrease in the first-order indicator (dK_j/dt takes on large values) and its slow change within one level (dK_j/dt takes on small values) are possible. The case $dK_j/dt \gg dK_i/dt$ corresponds both to a strong positive impact of the first-order indicator and its negative impact. The condition for the occurrence of pseudo-security

$$\Delta = \left(x_j - x_i\right) > 0\,, \vartheta_j < 0\,. \tag{8}$$

Type A2: a decrease in the main indicator and an increase in the first-order indicator. This case is characterized by different signs of the rate of the indicators $\vartheta_i < 0, \vartheta_j > 0$. A sharp increase in the first-order indicator and its slow change are also possible. The case $dK_j/dt \gg dK_i/dt$ corresponds to both a strong positive impact of the first-order indicator and its negative impact. In this case, pseudo-security takes the form

$$\Delta = \left(x_j - x_i\right) < 0\,, \vartheta_j > 0\,. \tag{9}$$

Type A3: a decrease in the main indicator and stationary behaviour of the first-order indicator: $\vartheta_i < 0, \vartheta_j = 0$. In this case, pseudo-security is absent.

Type B1: a decrease in the main indicator and increase in the first-order indicator$\vartheta_i > 0, \vartheta_j < 0$. This case is characterized by different values of the signs of the indicator rates. A sharp increase in the primary indicator and its slow change are also possible. The expression describing pseudo-security has the form

$$\Delta = \left(x_j - x_i\right) > 0\,, \vartheta_j < 0\,. \tag{10}$$

Type B2: a decrease in the main indicator and an increase in the first-order indicator $\vartheta_i > 0, \vartheta_j > 0$. This case is characterized by a negative value of the rate $\vartheta_i > 0$.

Both a sharp decrease in the first-order indicator (dK_i/dt takes on large values) and its slow change within one level (dK_i/dt takes on small values) are possible. In this case, pseudo-security corresponds to

$$\Delta = \left(x_j - x_i\right) < 0\,, \vartheta_j > 0\,. \tag{11}$$

Type B3: a decrease in the main indicator and stationary behaviour of first-order indicator $\vartheta_i > 0, \vartheta_j = 0$. In this case, the main indicator *is maintained* by the first-order indicator.

Type C1: a decrease in the main indicator and stationary behaviour of the first-order indicator $\vartheta_i = 0, \vartheta_j < 0$. This process reveals *positive influence* of the first-order indicator on the main indicator. However, *cases of negative impact on the main indicator are also possible.*

Type C2: a decrease in the main indicator and stationary behaviour of the first-order indicator $\vartheta_i = 0, \vartheta_j > 0$. A sharp increase in the first-order indicator and its slow change are also possible.

Type C3: a decrease in the main indicator and an increase in the first-order indicator $\vartheta_i = 0, \vartheta_j = 0$. This condition is characterized by the absence of pseudo-security.

The next stage in our calculations was to obtain a generalized normalized assessment of the economic security of the subjects of the Ural Federal District (Table 3).

Table 3. Generalised normalised evaluation of the economic security of the subjects of the Ural Federal District.

Years / **Subjects of the UFD**	**2008**	**2009**	**2010**	**2016**	**2017**	**2018**
Sverdlovsk Oblast (stat. data)	0.753 **PC3**	1.116 **C1**	0.639 **PC2**	0.566 **PC2**	0.501 **PC2**	0.5O6 **PC2**
Sverdlovsk Oblast (express diagnostics taking into account pseudo-security)	0.953 **PC3**	0.844 **PC3**	0.906 **PC3**	0.734 **PC3**	0.613 **PC2**	0.667 **PC3**
Pseudo-security	**0.0341**	**-0.046**	**0.0454**	**0.0285**	**0.019**	**0.0274**
Trend change in the indicator	0.1403	-0.191	0.187	0.1176	0.078	0.113
Error of transition from 43 indicators to 8 indicators	0.026	-0.035	0.035	0.022	0.015	0.021
Chelyabinsk Oblast (stat. data)	1.013 **C1**	1.309 **C1**	0.914 **PC3**	0.947 **PC3**	0.731 **PC3**	0.781 **PC3**
Chelyabinsk Oblast (express diagnostics taking into account pseudo-security)	0.817 **PC3**	0.623 **PC2**	0.679 **PC3**	0.815 **PC3**	0.828 **PC3**	0.874 **PC3**
Pseudo-security	**-0.033**	**-0.117**	**-0.04**	**-0.0224**	**0.017**	**0.0157**
Trend change in the indicator	-0.137	-0.48	-0.165	-0.0923	0.068	0.0648
Error of transition from 43 indicators to 8 indicators	-0.025	-0.089	-0.031	-0.017	0.013	0.012
Khanty-Mansi Autonomous Okrug (KhMAO) (stat. data)	1.072 **C1**	1.082 **C1**	1.066 **C1**	1.187 **C1**	1.116 **C1**	1.154 **C1**
Khanty-Mansi Autonomous Okrug (KhMAO) (express diagnostics taking into account pseudo-security)	0.630 **PC2**	0.511 **PC2**	0.548 **PC2**	0.930 **PC3**	0.893 **PC3**	1.033 **C1**
Pseudo-security	**0.0751**	**0.0971**	**0.0881**	**0.0436**	**0.038**	**0.0206**
Trend change in the indicator	0.3094	0.3999	0.3628	0.1796	0.156	0.0846
Error of transition from 43 indicators to 8 indicators	0.057	0.074	0.067	0.033	0.029	0.016
Yamalo-Nenets Autonomous	1.249	1.241	1.122	1.219	1.153	1.048

Okrug (YNAO) (stat. data)	**C1**	**C1**	**C1**	**C1**	**C1**	**C1**
Yamalo-Nenets Autonomous Orkug (YNAO) (express diagnostics taking into account pseudo-security)	0.791 **PC3**	0.816 **PC3**	0.838 **PC3**	0.884 **PC3**	0.795 **PC3**	0.866 **PC3**
Pseudo-security	**0.0778**	**0.0722**	**0.0483**	**0.0569**	**0.061**	**0.031**
Trend change in the indicator	0.3203	0.2974	0.199	0.2344	0.25	0.1275
Error of transition from 43 indicators to 8 indicators	0.059	0.055	0.037	0.044	0.046	0.024
Tyumen Oblast (south) (stat. data)	1.064 **C1**	1.063 **C1**	1.043 **C1**	0.983 **PC3**	1.050 **C1**	1.103 **C1**
Tyumen Oblast (south) (express diagnostics taking into account pseudo-security)	0.805 **PC3**	0.891 **PC3**	0.948 **PC3**	1.129 **C1**	1.076 **C1**	1.132 **C1**
Pseudo-security	**0.044**	**0.0292**	**0.0162**	**-0.0249**	**-0.00441**	**-0.005**
Trend change in the indicator	0.1812	0.1202	0.0666	-0.1025	-0.01817	-0.02
Error of transition from 43 indicators to 8 indicators	0.034	0.022	0.012	-0.019	-0.003	-0.004
Kurgan Oblast (stat. data)	1.100 **C1**	1.268 **C1**	1.263 **C1**	1.084 **C1**	1.263 **C1**	1.067 **C1**
Kurgan Oblast (express diagnostics taking into account pseudo-security)	1.214 **C1**	1.124 **C1**	1.255 **C1**	1.076 **C1**	1.023 **C1**	1.069 **C1**
Pseudo-security	**-0.019**	**0.0244**	**0.0014**	**0.0013**	**0.045**	**-0.00042**
Trend change in the indicator	-0.08	0.1006	0.0058	0.0053	0.187	-0.00174
Error of transition from 43 indicators to 8 indicators	-0.015	0.019	0.001	0.001	0.035	0.000

According to Table 3, pseudo-security tends to distort the state of the socio-economic development of the subjects of the Ural Federal District. For example, for the Sverdlovsk Oblast during the 2016–2018 period, the value of the normalized assessment of economic security (in express diagnostics, the level of PC3 in comparison with the statistics, the level of PC2) was deteriorated. One can also note a positive effect of pseudo-security (Chelyabinsk Oblast in 2008–2009, PC3 determined by express diagnostics, while C1 given by statistical data).

Due to interaction, the Sverdlovsk Oblast and the Chelyabinsk Oblast showed an improved normalised evaluation compared to the statistical data (an improvement in the value by 2–10%). This was contributed by the high rate (overcoming 3 crisis levels) of the indicator “The ratio of per capita income to the subsistence level”.

For the Khanty-Mansi Autonomous Okrug and Yamalo-Nenets Autonomous Okrug, interaction also resulted in an improved normalised evaluation compared to the statistical data for the entire time interval (an improvement in the value by 15–45%). These areas are characterised by a low rate of development of the generalised normalised evaluation, which takes a value in the range from 0.1 to 0.3.

The Kurgan Oblast and the south of the Tyumen Oblast are typical representatives of the Ural Federal District. The Kurgan Oblast is characterised by stationary behaviour of the normalized assessment and its weak change (fluctuations in values within 2–5%). For the south of the Tyumen Oblast in 2008-2010, an improved situation is characteristic, while the data of the conducted express diagnostics and statistical data for 2016–2018 showed little difference (minimum deviation 1–3%).

5 Conclusion

It was possible to simulate extreme changes in individual modules and system of indicators, based on the methods of the shear cross-correlation function.

The behaviour of the types of indicators is described by characteristics: the rate of change of the indicator, the scalar speed function and potential energy of interaction.

We conducted calculations of the presence of pseudo-security both within the structure of indicators and in the express diagnostics of the economic security of the subjects of the Ural Federal District for the period from 2000 to 2018 (with a focus on the crisis years for the economy).

The obtained results can be used in the current assessment and forecasting of the state of a region's socio-economic system.

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